Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. *(Currently amended)*

A method of producing hydrogen gas from a hydrocarbon gas and steam comprising:

(a) forming a fluidized bed of a suitable particulate catalyst in a reactor[[,]];

(b) ~~wherein~~ deploying part of the catalyst ~~is disposed~~ in the reactor in ~~two reaction modes, the first being an~~ a first endothermic dehydrogenation reaction mode; and

(c) deploying part of the catalyst in the reactor in ~~the~~ a second ~~being an~~ exothermic oxidation or partial oxidation reaction mode, said second exothermic dehydrogenation reaction mode being physically separated from the first endothermic dehydrogenation reaction mode but enabling the circulation of particles and gases between the first and second modes;

(d) introducing a mixture of steam and hydrocarbon gas into the bottom of the fluidized bed to fluidize the particulate catalyst and form the fluidized bed, reacting the steam and hydrocarbon gas within the first endothermic dehydrogenation reaction mode to produce hydrogen gas[[,]];

(e) separating said hydrogen gas from other gases in the first endothermic dehydrogenation reaction mode as molecular or atomic hydrogen through a perm-selective membrane that is located in the first endothermic dehydrogenation reaction mode, said perm-selective membrane permitting ~~permits~~ the transfer of hydrogen therethrough while minimizing the transmission therethrough of the other gases in the endothermic dehydrogenation reaction mode[[,]];

(f) introducing oxidant ~~in~~ into the second exothermic oxidation or partial oxidation reaction mode, and mixing the oxidant ~~same~~ with other gases in the second exothermic oxidation and partial oxidation mode[[,]]; and

(g) directing resultant ~~oxidized gases and~~ heated particulate catalyst to the first endothermic dehydrogenation reaction mode.

2. *(Original)*

A method as defined in claim 1 wherein the first endothermic dehydrogenation mode and the second exothermic oxidation or partial oxidation mode are separated by a barrier.

3. *(Original)*

A method as claimed in claim 2 wherein gases circulate upwards through the first endothermic dehydrogenation mode which contains vertically disposed perm-selective membrane surfaces and downwards through the second oxidation or partial oxidation mode.

4. *(Original)*

A method as claimed in claim 2 wherein gases circulate downwards through the first endothermic dehydrogenation mode which contains vertically disposed perm-selective membrane surfaces and upwards through the second oxidation or partial oxidation mode.

5. *(Original)*

A method as claimed in claim 3 wherein the particulate catalyst circulates upwards through the first endothermic dehydrogenation mode which contains vertically disposed perm-selective membrane surfaces and downwards through the second oxidation or partial oxidation mode.

6. *(Original)*

A method as claimed in claim 3 wherein the particulate catalyst circulates downwards through the first endothermic dehydrogenation mode which contains vertically disposed perm-selective membrane surfaces and upwards through the second oxidation or partial oxidation mode.

7. *(Original)*

A method as claimed in claim 2 wherein the oxidant is provided in a mixing zone above the surface of the membrane and the barrier.

8. *(Original)*

A method as claimed in claim 2 wherein the oxidant is provided in a solids downflow that surrounds the first dehydrogenation reaction mode.

9. *(Original)*

A method as claimed in claim 1 wherein the oxidant is air, oxygen enriched air or pure oxygen.

10. *(Currently amended)*

A method as claimed in claim 1 wherein a sweep gas is used to convey the hydrogen gas from the perm-selective membrane surfaces after permeating through the membrane.

11. *(Currently amended)*

A method as claimed in claim 1 wherein particulate catalyst is separated from the ~~other~~ non-permeable gases before they are conveyed from the process.

12. *(Original)*

A method as claimed in claim 1 wherein the particulate catalyst circulation rate is controlled by supplementary aeration or fluidizing gas introduced through gas distributors or nozzles.

13. *(Withdrawn)*

An apparatus for producing hydrogen from steam and hydrocarbon gas comprising:

(a) a reaction vessel enclosing a fluidizable catalyst bed of particulate catalyst;

(b) an inlet for introducing a mixture of steam and hydrocarbon gas at the base of the reaction vessel, and fluidizing the catalyst bed;

(c) a perm-selective membrane located in the central area of the reaction vessel;

(d) a barrier with top and bottom openings enclosing the sides of the perm-selective membrane, the mixture of steam and hydrocarbon gas passing upwardly from the open bottom through the interior of the barrier, the fluidized catalyst bed and the perm-selective membrane;

(e) at least one inlet in the wall of the reaction vessel for introducing oxygen or oxygen enriched air into the fluidized catalyst bed between the barrier and the interior of the walls of the reaction vessel;

(f) an outlet for conveying hydrogen from the apparatus; and

(g) an outlet for conveying product gases from the apparatus.

14. *(Withdrawn)*

An apparatus as claimed in claim 13 including a series of spaced perm-selective membranes located in the interior of the barrier.

15. *(Withdrawn)*

An apparatus as claimed in claim 14 including an inlet for sweep gas to be introduced into the perm-selective membranes and purging the perm-selective membranes of hydrogen, and an outlet for enabling the sweep gas and the purged hydrogen to be withdrawn from the reaction vessel.

16. *(Withdrawn)*

An apparatus as claimed in claim 13 wherein the barrier is a vertical open-ended device which houses the perm-selective membranes, and a portion of the particulate catalyst fluidized bed, the device extending vertically with the open bottom end being located above the inlet for introducing steam and hydrocarbon gas at the base of the reaction vessel, and enabling the steam and hydrocarbon gas to flow upwardly through fluidized particulate catalyst located in the interior of the cylinder, and the exterior sides of the device and the interior walls of the reaction vessel forming an annular space for downward flow of gas through fluidized particulate catalyst located in the annular space.

17. *(Withdrawn)*

An apparatus as claimed in claim 16 including a freeboard zone located below the top of the reaction vessel and above the top surface of the fluidized bed, the freeboard zone containing a separator which separates particulate catalysts from product gas being withdrawn through the outlet (g) at the top region of the reactor vessel.

18. *(Withdrawn)*

An apparatus as claimed in claim 17 including a plurality of inlets (e) for introducing air, oxygen or oxygen enriched air into the annular space between the walls of the gas barrier and the interior walls of the reaction vessel.

19. *(Withdrawn)*

An apparatus as claimed in claim 13 including additional aeration or fluidizing gas distributors for controlling solid particulate catalyst circulation rates in the apparatus.

20. *(Withdrawn)*

An apparatus as claimed in claim 17 wherein the separator is a cyclone or a hot filter.

21. *(New)*

A method of producing hydrogen gas from a hydrocarbon gas and steam comprising:

(a) forming a fluidized bed of a suitable particulate catalyst in a reactor;

(b) deploying a first part of the particulate catalyst in one volume of the reactor in a first endothermic dehydrogenation reaction mode; and

(c) deploying a second part of the particulate catalyst in a second volume of the reactor in a second exothermic oxidation or partial oxidation reaction mode, said second

exothermic oxidation or partial oxidation mode being physically separated from the first endothermic dehydrogenation reaction mode but enabling the circulation of particulate catalyst and gases between the first and second modes;

(d) introducing a mixture of steam and hydrocarbon gas into the bottom of the fluidized bed to fluidize the first and second parts of the particulate catalyst and form the fluidized bed, and reacting the steam and hydrocarbon gas within the first endothermic dehydrogenation reaction mode to produce hydrogen gas;

(e) separating said hydrogen gas from other gases in the first endothermic dehydrogenation reaction mode as molecular or atomic hydrogen through a plurality of vertically disposed perm-selective membranes that are located in the first endothermic dehydrogenation reaction mode, said perm-selective membranes permitting the transfer of molecular or atomic hydrogen therethrough while minimizing the transmission therethrough of the other gases in the endothermic dehydrogenation reaction mode;

(f) introducing air into the second exothermic oxidation or partial oxidation reaction mode, and mixing the air with other gases in the second exothermic oxidation and partial oxidation mode; and

(g) directing resultant particulate catalyst to the first endothermic dehydrogenation reaction mode wherein the particulate catalyst is circulated upwards through the first endothermic dehydrogenation mode and downwards through the second oxidation or partial oxidation mode.